On the Modelling of Oscillating Water Column (OWC) – based Converters

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Abstract: - The European Energy Road Map 2050 and the Spanish Renewable Energies Plan for 2011-2020 are promoting the use of renewable energies as a necessary path to achieve the greenhouse gas reduction target necessary to avoid the rising global warming, and in particular, the use of Ocean Energy. Within the different types of on-shore wave-based energy devices, Oscillating Water Column (OWC) converters are one of the more widely used ones. An OWC plant is basically composed by a capture chamber coupled to a turbo-generator module. This paper deals with the model development for on-shore OWC wave energy power devices.

Key-Words: - Modelling, Simulation, Control, OWC, Wave Energy, Renewable Energy

1 Introduction

The aim of the OWC Nereida project, promoted by the Basque Energy Agency (EVE), is to demonstrate the feasibility of the OWC technology with Wells turbine power take-off into a newly constructed breakwater in Mutriku, in the north coast of Spain.

Fig. 1. Turbo-generator modules in Mutriku wave plant

It consists of 16 18.5kW turbines that provide a total power of 296kW, with an estimated production capacity of 600.000kWh per year (see Fig 1).

2 Plant Description

The OWC capture chamber consists of a fixed structure whose lower part is opened to the sea and it always remains under the Still Water Level (SWL) [1].

The pressure drop *dp* can be defined by means of the following equation [2,3]:

$$dp = C_a \frac{\rho b l_1 n}{2} \frac{1}{a_1} (v_t^2 + (r \cdot \omega_t)^2) \qquad (1)$$

Besides, the rotational movement of the turbine remains always unidirectional [4,5].

The turbo-generator module consists of a turbine and an induction generator [6]. Its function is to transform the oscillatory pressure drop into electrical power. For this purpose, diverse control strategies can be applied [7-18].

3 System Modelling

Different approaches have been used in the literature [19-26].

According by Airy linear theory, a wind wave can be described as an ideal sinusoidal wave [27]. From the wave equation, and taking into account the capture chamber geometry, it can be obtained the air-flow speed needed to determine (1):

$$v_t(t) = \frac{8awc}{\pi D^2} \cdot \sin\frac{\pi l}{cT}\cos\frac{2\pi}{T}t \qquad (2)$$

Accordingly, the rotational speed representing the other variable needed to compute the aforementioned *dp,* may be obtained by considering the mechanical equation of the turbo-generator:

$$H\dot{\omega}_t + F\omega_t + T_e = T_t \qquad (3)$$

In this way, an expression for the pressure drop, that composes the main variable to take into account when simulating control schemes over MOWC devices, may be obtained by considering the above equations jointly with the characteristic curves of the turbine at hand represented by *f*(·):

$$dp = f\left(\frac{v_t}{r \cdot \omega_t}\right) \cdot \frac{\rho b l_1 n}{2}\frac{1}{a_1}$$
$$\left(\left(\frac{8awc}{\pi D^2} \cdot \sin\frac{\pi l}{cT}\right)^2 \cos^2\frac{2\pi}{T}t + (r \cdot \omega_t)^2\right) \quad (4).$$

4 Conclusion

This paper has dealt with the modeling of OWC on-shore wave power plants. The results have been are particularized for the case of the Mutriku's MOWC power plant. Future research work will include the model for the wave, chamber and turbo-generator module implementation using a Characteristic Curve Tracking Control and its validation by means of experimental data.

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